92-04086/

CONFIDENTIAL REPORT

Testing of Air and Wood Samples, Air Tightness Levels, and Ventilation Rates in Dwellings at Weyakwin, Green Lake, and Pinehouse, Sask.

for

Saskatchewan Community Services - Housing Division

by

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SRC Publication No. I-4800-2-C-92
March 1992

INTRODUCTION

Staff at the Saskatchewan Community Services - Housing Division contacted the Building Science Division of the Saskatchewan Research Council (SRC) regarding air quality testing in homes in Weyakwin, Green Lake, and Pinehouse, Saskatchewan.

The homes in questions were built with preserved wood foundations. Questions had been raised regarding the wood preservative treatments used in the construction of the homes or that could have been applied post-construction.

Tests were performed to identify indoor air concentrations of pentachlorophenol (PCP), creosote and other hydrocarbons. Airtightness testing and ventilation rate measurements were also carried out in a number of the homes so as to quantify the amount of ventilation and compare this with national standards. In addition, several samples of wood products were extracted from the homes which had been previously identified as having either creosote or pentachlorophenol treated materials. These samples were also tested for offgassing.

METHODOLOGY

The tests were as follows:

1. AIR QUALITY TESTS

1) air quality in 16 houses in Weyakwin
2) air quality in 8 houses in Green Lake
3) air quality in 4 suites in Pinehouse

a. Creosote and total volatile organic compounds

A sorbent tube was used to gather air samples from the air inside the homes. Air was drawn through a Sopelco ORBO 32 sorbent tube at the rate of 1.0 litre/minute for approximately 5 hours in each dwelling. The sorbent tubes were then returned to the laboratory for analysis using a gas chromatograph flame ionization detector. The detector was able to spot the presence of benzene, toluene, ethyl benzene, xylene, gasoline and diesel.

b. Pentachlorophenol

To measure this chemical in the air, an impinger based system was used. Air was bubbled through an absorbing solution of 0.1 normal sodium hydroxide at a flow rate of 0.2 L/min for approximately five hours. After the five hour time interval, the solution was placed in a glass bottle with a teflon stopper and then returned to the laboratory for analysis.

2. CHEMICAL OFFGASSING FROM WOOD SAMPLES

In homes that had been previously identified as having either PCP or creosote, samples of untreated main floor joist blocking were removed and subjected to an offgassing test at the Product Research Laboratory at the Saskatchewan Research Council. This test was used to determine if the amounts of chemicals absorbed by these samples and re-emitted could cause a future problem in houses that have the original sources of PCP and or creosote removed.

3. AIRTIGHTNESS TESTING OF HOUSES

Five Houses in Weyakwin and three houses in Green Lake

The airtightness levels of a number of the houses was tested using the CGSB standard CAN/CGSB-149.10-86 protocol. Tests were done for 5 houses in Weyakwin and also for 3 houses in Green Lake. These homes were ones that have been identified as potentially having PCP or creosote treated materials. This test gives a measure of the leakiness of the dwelling, and provides an estimate of the air change rate.

4. AIR EXCHANGE TRACER GAS TESTING OF THE HOUSES

Five houses in Weyakwin and five houses in Green Lake

The outdoor air exchange rates of a number of houses were measured using nitrous oxide as a tracer gas. The nitrous oxide was placed in the home at an initial level of approximately 200 ppm. A Miran 1B gas analyzer was used to measure the concentration of the nitrous oxide over time. This measurement provides an independent estimate of the outdoor air exchange rate in the dwelling.

RESULTS

1. AIR QUALITY TESTS

The results of the monitoring are summarized in Table 1 in which values for pentachlorophenol (PCP), benzene, toluene, ethylbenzene, xylene, gasoline, diesel and total volatile organic compounds are reported for the houses in Weyakwin. Similar results are presented for Green Lake and Pinehouse with the exception that diesel fuel is not reported for those two communities. The values for pentachlorophenol are listed in micrograms per cubic meter ($\mu g/m^3$); and the other readings are in milligrams per cubic meter (mg/m^3).

The Weyakwin Houses were tested from December 18 to December 20, 1991. The Green Lake houses were tested January 8 to 10, 1992, and the Pinehouse suites were tested on January 15, 1992.

As can be seen from Table 1, the PCP values for all of the houses that were sampled were less than about 6 $\mu g/m^3$. In all cases, they were below the detection limit of the apparatus and the values are low as compared to threshold limit values that are set for occupational exposure limits. The threshold limit value for pentachlorophenol is 500 $\mu g/m^3$ and the highest single value measured was less than 6 $\mu g/m^3$.

The Threshold Limit Values (TLVs) are values that have been developed for occupational exposures, assuming healthy adults are working in the environment for an 8 hour daily, 40 hour weekly exposure. A list of TLV values for several compounds found in the houses is presented in Table 2. Normally the TLV values are not deemed to be suitable levels for residential exposures, as the residents could be exposed for 24 hours per day, and individuals that are unhealthy or infirm can be residing in the dwellings. It has been suggested that the TLVs should be divided by approximately 100 in order to have a safe level for occupants of residences.

For instance, a number of chemicals which have TLV values also have recommended maximum values for residential occupancy in Canada (Department of Health and Welfare, 1989).

The following listing presents values for TLVs and the Canadian Residential Guidelines.

	TLV	Residential Guideline	Ratio
	ppm	ppm	
Formaldehyde	1.0	0.1	10
Carbon dioxide	5000	3500	1.4
Sulfur dioxide	2.0	0.38	4.5
Nitrogen dioxide	3.0	0.05	60.0
Ozone	0.1	0.12	0.83
Carbon Monoxide	50.0	11.0	4.5
Acrolein	0.1	0.02	5.0
Acetaldehyde	100	5.0	20.0

As can be seen from the ratio of the TLV to the Residential Guideline, the Ratio varies from 0.83 to 60.0, with the residential value always lower with the exception of ozone.

For benzene, which is present in a number of compounds including gasoline and creosote, the values measured in the homes ranged from below the detection level to 2.86 mg/m³ (milligrams per cubic meter). The threshold limit value for benzene is 32 mg/m³ and for one house (house 12 on block 1 in Weyakwin), the value was equal to 2.86 mg/m³.

For toluene, the threshold limit value is 377 mg/m³ and the maximum value measured in the houses was 1.0 mg/m³, again in house 12 on block 1 in Weyakwin. Toluene is present in both creosote and gasoline.

For ethyl benzene, which is a constituent of gasoline, the values were found to range up to 0.364 mg/m³. The threshold limit value is 434 mg/m³. House 2 on block 4 in Weyakwin had the highest reading at 0.364 mg/m³.

For xylene, which has a TLV of 434 mg/m³, the maximum value measured in any of the houses occurred in house 12 on block 1 in Weyakwin. For this house the value was 1.19 mg/m³. Xylene is normally present in gasoline.

For gasoline, the threshold limit value is 890 mg/m³. For house 12 on block 1 in Weyakwin, the value measured was 200.7 mg/m³. A number of other houses in Weyakwin had relatively high gasoline readings inside the homes. House 2 on block 4 had a value of 18.2, house 4 on block 4 had a value of 9.6 and house 10 on block 1 had a value of 9.4 mg/m³. One house in Green Lake, 2 on block 14, had a value of 1.18 mg/m³.

In the Weyakwin houses, the diesel fuel levels in the air were measured as well. For these homes the diesel level ranged as high as 4.2 mg/m³. There are not any posted threshold limit values for diesel.

The following houses had the sum of the hydrocarbons (benzene, toluene, ethyl benzene, xylene, gasoline, and diesel) greater than 1 mg/m^3.

	House	Block	Sum of Hydrocarbons (mg/m^3)
WEYAKWIN	2	4	19.9
	7	3	4.5
	2	3	2.8
	4	4	11.5
	6	4	4.6
	7	2	1.2
	12	1	206.3
	10	1	10.1
GREEN LAKE	2	14	1.7

2. CHEMICAL OFFGASSING RATES FROM WOOD SAMPLES

Untreated wood samples were taken from a number of the houses in Weyakwin and Green Lake, and the samples were tested for offgassing of chemicals. This testing was done to determine if the wood in the house would be a substantial emitter of chemicals once the original sources of treated wood were removed.

The wood samples were taken from the floor joists blocking and the floor joists of the main floors of the houses.

Wood samples from the following houses were tested:

Weyakwin
- 11 on block 3
- 13 on block 3
- 2 on block 14
- 15 on block 8

Green Lake
- 4 on block 3
- 12 on block 8
- 9 on block 13
- 8 on block 10
- 3 on block 13
- 1 on block 12

In all the houses except house 11 on block 3 in Weyakwin, the chemical offgassing rates were below the detection level of the apparatus.

For house 11 on block 3, the following chemicals were detected in the chemical offgassing test:

Toluene	0.01 mg
Ethylbenzene	0.002 mg
Xylene	0.02 mg
Hydrocarbons	0.17 mg

House 11 on block 3 in Weyakwin was one of the houses that had been identified as having creosote in the basement wall studs.

House 13 on block 3 was also one of the houses that had been identified as having creosote in the basement wall studs. However, the sample of wood taken from the house did not have a detectable chemical level. This house had been vandalized, and a major part of the ceiling in the living room was completely removed. A window in the living room had been broken wide open. Thus, this house would have had a very high air exchange rate, and consequently it is unlikely that much of the creosote vapour would have remained in the house for very long.

In House 11 on block 3, a sample of the basement wall stud that had been coated with a creosote smelling compound was tested using a gas chromatograph/mass spectrometer. The compound on the studs was found to contain 44% pentacholorophenol.

3. AIRTIGHTNESS TESTING OF HOUSES

The airtightness levels were found to be as follows:

House	Block	Airtightness Level (air changes/hr at 50 pascals)
Weyakwin		
2	4	3.86
11	3	5.78
4	4	3.56
6	4	4.13
10	3	3.16
Green Lake		
3	13	2.82
4	3	3.01
2	14	2.37

4. AIR EXCHANGE TRACER GAS TESTING OF HOUSES

The air change rates as measured by the nitrous oxide tracer gas tests were as follows:

House	Block	Air exchange Level (air changes/hr)	Temperature Difference (Inside-outside) °C
Weyakwin			
2	4	0.77	26
11	3	1.26	28
4	4	0.57	29
6	4	0.39	31
10	3	0.26	29

Green Lake

1	12	0.48	30
12	8	0.36	32
3	13	0.44	29
15	8	0.49	36
2	14	0.37	25

DISCUSSION

1. AIR QUALITY

In a number of the houses, the sum of the individual chemical components in the air was relatively high compared to normally accepted values for chemicals in the air in homes. For instance, in Weyakwin, house 2 on block 4 had a total concentration of the hydrocarbons (benzene, toluene, ethyl benzene, xylene, gasoline and diesel) of approximately 20 mg/m^3. In a recent survey of chemical levels inside 45 homes in Saskatchewan and Ontario, the average level of the contaminants in the air was approximately 0.5 mg/m^3. Another home which had fairly high values was house 4 on block 4 in Weyakwin, which had approximately 11 mg/m^3. The house that had the highest hydrocarbon readings was house 12 on block 1 in Weyakwin, with readings of 206 mg/m^3 of total hydrocarbons. Another house that had fairly high readings was house 10 on block 1 in Weyakwin with approximately 10 mg/m^3 total hydrocarbons.

House 11 on block 3 was known to have creosote treated basement wall studs and yet its total hydrocarbon level was relatively small at 0.56 mg/m^3.

The house with the highest value in Green Lake (House 2 on 14) had 1.65 mg/m^3 of hydrocarbons.

The suites at Pinehouse which were checked out had low levels for all of the contaminants. In each case, they were measured below the detection level for the apparatus. However, the person doing the testing noted that there was a noticeable odor in all the suites tested.

2. CHEMICAL OFFGASSING FROM WOOD SAMPLES

The only untreated wood sample that had offgassing at a detectable level was from house 11 on 3 in Weyakwin. House 11 on 3 was also identified as having creosote in the basement wall studs.

3. AIRTIGHTNESS TESTING OF HOUSES

The airtightness values measured in the Weyakwin and Green Lake houses are in the same range as houses built in Saskatoon over the period from 1961-1980. The Saskatoon houses of that time period had an average air tightness level of 3.6 air changes per hour (Dumont, Orr and Figley, 1981), and 95.5% of the houses in the Saskatoon sample had values between 1.03 and 6.11 air changes per hour at 50 pascals. All of the houses fell within the range of the Saskatoon houses. House 11 on block 3, which had the highest air change/hr reading (5.78 air changes/hr at 50 pascals), had been modified. A chute for directly throwing wood into the basement level had been added after the house was built. Based on the above readings, the airtightness levels of the Weyakwin and Green Lake houses are not typical of houses built during that period of time in Saskatchewan.

4. AIR EXCHANGE TRACER GAS TESTING OF HOUSES

The air exchange values measured in the Weyakwin and Green Lake houses during the months of December and January were generally larger than the minimum value of 0.35 air changes/hour recommended in the Canadian Standards Association Standard F326. However, the houses would not meet the present standard for mechanical ventilation, which calls for a minimum installed capacity of exhaust fans of 0.35 air changes per hour. In warmer weather, the air change rates of the Weyakwin and Green Lake houses would be lower, as the temperature difference between inside and outside would be lower.

CONCLUSIONS

1. Two houses (11 on 3 and 13 on 3 in Weyakwin) were positively identified as having creosote on the basement wall studs.

2. Nine out of the 28 dwellings tested had the sum of the following hydrocarbons (benzene, toluene, ethyl benzene, xylene, gasoline and diesel) greater than 1 milligram/m^3. A good number of the houses had odours which were likely caused by the storage or spillage of petroleum products such as fuel oil, gasoline, varsol, and motor oil.

3. One house (12 on 1 in Weyakwin) had a very high level of gasoline (200.7 mg/m^3) measured.

4. Untreated wood materials taken from a number of the houses did not have detectable levels of offgassing, with the exception of wood material taken from house 11 on 3 in Weyakwin.

5. Levels of pentachlorophenol measured in the houses were all below the detectable level of the apparatus used (6 micrograms/m^3 or less.) These values are low compared with the Threshold Limit Value of 500 micrograms/m^3.

RECOMMENDATIONS

1. Houses with creosote identified in the basement walls.

   Of the houses tested in Weyakwin, units 11 on 3 and 13 on 3 were identified as having creosote treated wall studs. The creosote material was also contaminated with pentachlorophenol.

   For these houses, it is recommended that the basements be removed from the houses, and that the wood materials that have been treated with creosote/PCP be disposed of in a manner acceptable to the Saskatchewan Department of the Environment.

   The upper parts of these houses have materials that have been exposed to creosote/PCP, and it is recommended that if the upper parts of these houses (main floor joists and everything above) are reused that the following be done:

   a. All particle board on the walls and ceilings be removed and replaced with gypsum board. A sample of particle board removed from unit 11 on 3 was found to contain

measurable quantities of toluene, ethyl benzene, xylene, and hydrocarbons.

b. All wood in the house be coated with an oil based paint or other sealing agent.

c. A ventilation system able to meet the requirements of the 1990 National Building Code of Canada be installed.

2. Houses with higher hydrocarbon levels

A number of the houses had hydrocarbon levels that were above 1.0 milligrams/m^3. From the air sampling done, it is likely that these high readings were caused by compounds such as gasoline, diesel (fuel oil), and cleaning solvents. It is recommended that a thorough check be done in each of these homes to identify the sources of the hydrocarbons. In addition, it is recommended that the basement walls in these houses be opened and that samples of wood be extracted and analyzed for chemical offgassing.

The houses with the sum of the hydrocarbon levels above 1 mg/m^3 were as follows:

	House	Block	Sum of Hydrocarbons (mg/m^3)
Weyakwin	2 on 4		19.9
	7 on 3		4.5
	2 on 3		2.8
	4 on 4		11.5
	6 on 4		4.6
	7 on 2		1.2
	12 on 1		206.3
	10 on 1		10.1
Green Lake	2 on 14		1.7

3. Other Houses

The remaining houses tested had relatively low hydrocarbon levels and also PCP levels that were below the detection level of the instrumentation used. However, there were still noticeable odours in these houses. Many of the Green Lake

Houses were in this category.

It may be possible to reduce the odour levels in these houses with increased ventilation.

It is recommended that a ventilation system able to meet the 1990 National Building Code be installed in these houses.

4. Occupants of houses with high hydrocarbon levels

   It is recommended that the occupants of those houses with high hydrocarbon levels be examined by a physician with expertise in the area of health effects of air contaminants.

5. Home Occupant Education

   A short educational sheet on the need for care with the use of solvents and petrochemical products inside the houses should be developed and distributed to the occupants of the houses in these communities. A number of the houses were seen to have the following sources of petroleum chemicals:

   a. Fuel oil spills
   b. Storage of gasoline powered chain saws.
   c. Disassembled automobile engines and small gasoline motors.

LIST OF REFERENCES

1. R.S. Dumont, H.W. Orr, and D.A. Figley, Air Tightness Measurements of Detached Houses in the Saskatoon Area, Division of Building Research, National Research Council, Building Research Note Number 178, Ottawa, 1981

2. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH, 6500 Glenway Ave., Bldg. D-7, Cincinnati, OH, U.S.A. 45211-4438 (1991)

TABLE 1. MEASURED VALUES OF PCP AND HYDROCARBONS

SAMPLE	HOUSE CODE	BLOCK	SUITE	PCP ug/m3	Benzene mg/m3	Toluene mg/m3	Ethyl Benzene mg/m3	Xylene mg/m3	Gasoline mg/m3	Diesel mg/m3	Sum Hydrocarbons mg/m3
WEYAKWIN											
A	2	4		< 3.3	0.026	0.265	0.364	0.861	18.212	< 0.17	19.89
B	7	3		< 2.9	0.006	0.030	0.027	0.091	< 0.151	4.23	4.53
C	6	3		< 3.3	0.013	0.033	0.013	0.033	0.264	0.50	0.85
D	8	2		< 3.6	0.010	0.033	0.020	0.098	0.163	0.46	0.78
E	2	3		< 1.5	0.022	0.108	0.036	0.252	0.432	1.98	2.83
F	11	3		< 3.3	< 0.003	0.020	0.007	0.030	< 0.167	0.33	0.56
G	4	4		< 3.2	0.010	0.257	0.354	1.029	9.646	< 0.16	11.46
H	6	4		< 3.2	0.013	0.097	0.032	0.388	0.550	3.56	4.64
I	10	3		< 3.3	0.007	0.033	<0.003	0.030	< 0.166	0.46	0.70
J	7	2		< 3.4	0.023	0.067	0.023	0.134	0.369	0.54	1.15
K	10	2		< 3.3	0.010	0.099	0.007	0.020	0.330	< 0.17	0.63
L	3	2		< 3.6	< 0.004	< 0.004	<0.004	0.007	< 0.182	< 0.18	0.38
M	2	2		< 3.7	< 0.004	< 0.004	<0.004	< 0.004	0.000	0.00	0.01
N	12	1		< 3.7	2.862	1.004	0.297	1.190	200.743	< 0.19	206.28
O	10	1		< 3.8	0.015	0.075	0.113	0.301	9.398	< 0.19	10.09
P	9	2		< 3.3	< 0.003	0.007	0.013	0.033	0.000	0.00	0.06
GREEN LAKE											
R	1	12		< 3.4	0.007	0.010	<0.003	0.010	0.270		0.30
S	12	8		< 3.1	< 0.003	0.006	<0.003	0.006	< 0.156		0.17
T	3	13		< 3.0	< 0.003	0.006	<0.003	0.006	< 0.148		0.17
U	4	3		< 2.8	0.006	0.011	0.006	0.028	0.000		0.05
V	8	10		< 3.5	< 0.004	0.011	<0.004	0.011	0.000		0.03
W	15	8		< 3.9	0.016	0.039	0.008	0.079	0.000		0.14
X	9	13		< 6.1	< 0.006	< 0.006	<0.006	< 0.006	< 0.307		0.33
Y	2	14		< 2.7	0.027	0.241	0.019	0.188	1.180		1.65
PINEHOUSE			SUITE								
Z	6	2	4	< 4.0	< 0.004	< 0.004	<0.004	< 0.004	< 0.200		< 0.22
AA	6	2	2	< 3.8	< 0.004	< 0.004	<0.004	< 0.004	< 0.192		< 0.21
BB	6	2	1	< 4.3	< 0.004	< 0.004	<0.004	< 0.004	< 0.215		< 0.23
CC	6	2	3	< 4.4	< 0.004	< 0.004	<0.004	< 0.004	< 0.222		< 0.24

1 mg/m^3 = 1000 ug/m^3 The symbol "<" means less than

Table 2. THRESHOLD LIMIT VALUES FOR READINGS OF HYDROCARBONS AND PCP

	mg/m^3
Benzene	32
Toluene	377
Ethylbenzene	434
Xylene	435
Gasoline	890
Diesel	N/A
PCP	0.5

1 mg/m^3 = 1000 $\mu g/m^3$